

VI

Comparison of Different Methods of Grading a Level Turn Task on a Flight Simulator by Bruce E. Heath, Tomyka Crier, Proceedings, Huntsville Simulation Conference, Huntsville, Alabama, October 2003, 7 pages.

Blank Page

COMPARISON OF DIFFERENT METHODS OF GRADING A LEVEL TURN TASK ON A FLIGHT SIMULATOR

Bruce E. Heath and Tomyka Crier
Aerospace Science Engineering Department
Tuskegee University
Tuskegee, Alabama 36088
Email: bheath35@hotmail.com

KEYWORDS

Training Simulator, Level Turn, Performance measures, Novice pilots

ABSTRACT

With the advancements in the computing power of personal computers, pc-based flight simulators and trainers have opened new avenues in the training of airplane pilots. It may be desirable to have the flight simulator make a quantitative evaluation of the progress of a pilot's training thereby reducing the physical requirement of the flight instructor who must, in turn, watch every flight.

In an experiment, University students conducted six different flights, each consisting of two level turns. The flights were three minutes in duration. By evaluating videotapes, two certified flight instructors provided separate letter grades for each turn. These level turns were also evaluated using two other computer based grading methods. One method determined automated grades based on prescribed tolerances in bank angle, airspeed and altitude. The other method used was deviations in altitude and bank angle for performance index and performance grades.

INTRODUCTION

With the invention of faster personal computers it has become possible to use flight simulation on cost effective computers. Because the advantages of training on flight simulators includes savings in time and money, computer based training provides researchers with increased opportunity to investigate such factors that may affect flying and pilot training. Investigation of scoring practices is needed to evaluate different strategies in training. Computerized scoring is desirable as it could, if properly implemented, give immediate feedback about the pilot's performance.

Straight and level flight, climb, descent and level turn are regarded as the four basic flight maneuvers in a Federal Aviation Administration (1995) publication on private pilot practical test standards. For evaluation of a trainee's flight, it prescribes certain tolerances in the basic flight parameters. Following FAA's guidelines, an expert flight instructor directly evaluates the performance of a trainee's flight.

For modern training simulators, Vreuls and Obermayer (1985) emphasize the need of automated performance measures

as a substitute for the evaluation of performance by direct observations. They present several benefits of the automated performance measures. The authors have suggested several methods for validating automated measures. One method includes the need of experts to judge performance quality, and then determine which measures correlate with the experts' judgments.

Williams (2000) used grade points for flying performances on the simulator. To validate the automated scoring, several flights flown on a simulator were simultaneously evaluated by the computer and by a certified flight instructor. He found acceptable correlation for straight and level flights but low correlation for climb, descent and turning maneuvers. Ali, Khan, Rossi, Crane, Guckenburger and Bageon (2001) proposed that a performance measure which represents an increase or decrease of performance at different stages of training is a valid measure to assess progress in training even if the measure is not adopted for certifying a trained pilot.

We used an RMS value of deviation in bank angle and altitude as a performance index. We compared the automated grades, and performance index with the instructors' letter grades. Following Williams (2000) method, we used grade points for our automated grade. Furthermore, two instructors independently evaluated the flights and gave letter grades.

In an attempt to create a numerical grade using the RMS value, performance index and automated grades were graphed and a regression line was drawn.

University students performed six different flights. Each flight consisted of two level turns. For a level turn task, two kinds of performance measures were devised, automated grades and performance index. In the automated grades, A, B, C and D grades were based on prescribed tolerances in bank angle, and altitude. A performance index was based on deviations in bank angle and altitude. Video recordings were made of the HUD and relevant instrument panel gauges. Two certified flight instructors independently evaluated the videos of the flights. This study attempts to correlate the performance index, the automated grades and instructors' evaluations.

EQUIPMENT

The experiment was performed in the Flight Vehicle Design Lab at Tuskegee University. Flights were conducted on a training simulator that had LiteFlite version 3.3 installed. The PCs for the simulator were two Heavy Metal computers made by Quantum 3D. Each computer has 2 processors running at 400Mhz, 400MB RAM, and has three extra video cards for the Out of the Window (OTW) view. Three display monitors showed the OTW view. The center monitor displayed not only a forward view, but also a heads up display (HUD). Figure 1 shows the entire setup including the four monitors and a moving map display monitor on the right of the picture. The moving map display was not used in this experiment. Figure 2 shows a close up of the inside the cockpit view screen. The joystick was a Saitek X36F and throttle was Saitek X35T controller. Rudder pedals used were from CH products. Williams

(2000) gave more details on the fidelity of the equipment used.

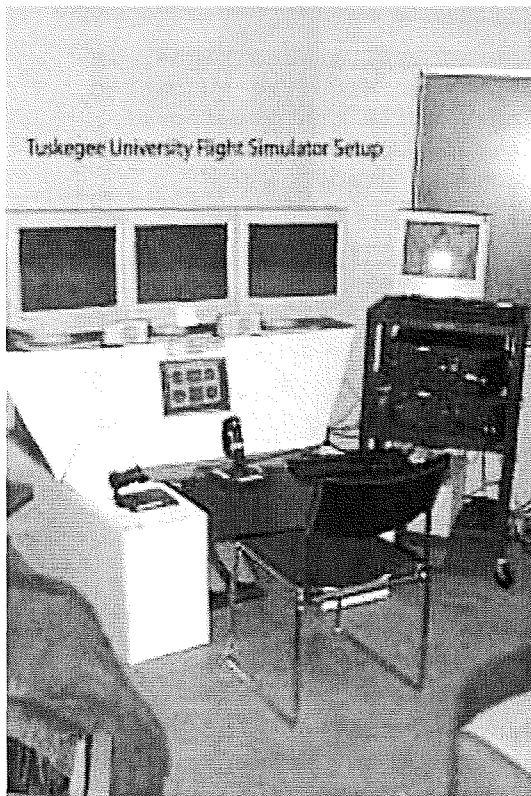


Figure 1: Simulator setup including OTW view.

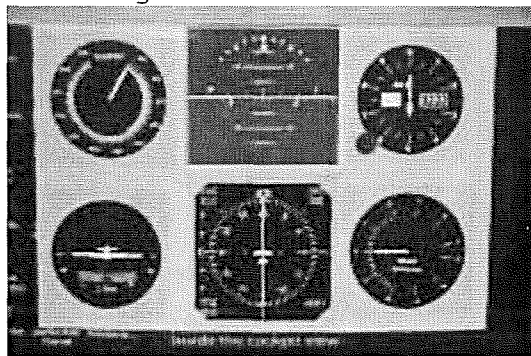


Figure 2. Instrument Panel (Inside the cockpit view)

METHOD

Level turn task

This task was to be a level turn from 0 degrees to 180 degrees heading. The pilot, in this scenario, was to bank the airplane 30 degrees to the right

or left while flying at a speed of 90 knots. After the plane reached 180 degrees, the pilot was to bank in the same or opposite direction at a new bank angle of 45 degrees. The pilot was to hold the bank angle and speed until the airplane reached 360 degrees. After that time the pilot was to fly straight and level until the simulator stopped.

Each turn task was recorded by videotaping the HUD on the center monitor and the turn and bank instruments on the inside the cockpit monitor.

Instructors' grades

Two Certified Flight Instructors were then asked to view the videotaped sessions and write down a score (A,B,C,D,E or F) for, in turn, altitude, bank angle and airspeed over the time slots: 21 - 72 seconds, and approximately 120 - 171 seconds. These time intervals represented each of the two turns in a flight. An average of the three-parameter grades was calculated to represent the instructors' grade for a single turn. This was used as a data point. For the six flights there were 12 data points representing all turns.

Automated grades

The automated grade criteria were based on the requirements of 90 knots ± 3 knots in airspeed, 30 or 45 degrees ± 3 degrees in bank angle and 10000 ft ± 50 feet in altitude. Flight parameters within these limits were graded as 'A'. Deviations of ± 6 knots in airspeed, ± 6 degrees in bank angle and ± 100 feet in altitude were graded as 'B'. Deviations of ± 9 knots in airspeed, ± 9 knots in bank angle and ± 150 knots in altitude were graded as 'C'. Deviations of ± 12 knots in airspeed, ± 12 degrees

in bank angle and ± 200 feet in altitude were graded as 'D'. And, deviations of < -12 knots and $> +12$ knots in airspeed, -12 degrees and $> +12$ degrees in bank angle and < -200 feet and $> +200$ feet in altitude were graded as 'F'. The flight parameters were grading every three seconds. An average grade was then calculated for each of the turns.

Performance Index and Performance Grades

The performance index of the level turn flights were obtained by taking the root of the squared sum of the average deviations of the heading, altitude, and airspeed.

It should be noted that as a performance index (P.I.) increases, the performance of a pilot actually decreases. For that reason, in order to obtain some reasonable 4 point scale score we used an equation of the form $A/(B+P.I.)$ and the values tried for A and B were such that $B = 0.25 \cdot A$.

RESULTS AND DISCUSSION

Our set of evaluation consisted of 12 data points representing 6 flights with 2 turns in each flight. Five such sets of evaluation were: Automated grades, instructor 1 and instructor 2 grades, performance index and performance grade. A comparison of the different evaluations that were made is as follows.

Automated Grade versus Instructors' grades

The comparison of the overall automated grade vs. the instructors' grades for each of the turns is shown as scatter charts in Figs. 3 and 4. As can be seen from the scatter plots, most of the scores are in the 2.0 or below range. This was

expected, as the subjects were novice pilots. However, the two instructors' scores were somewhat inconsistent with one another. In general, instructor#1 graded higher in comparison with the automated grade, while the grading of instructor#2 was lower than the automated grade.

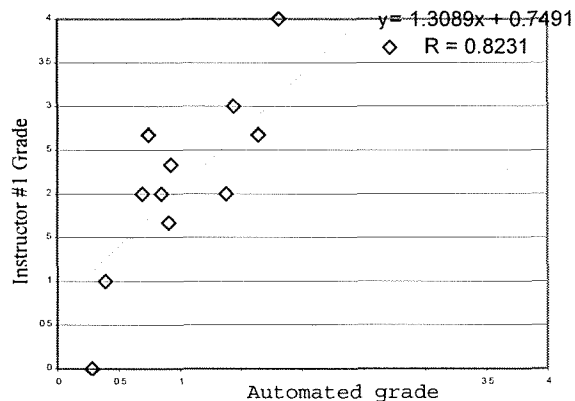


Figure 3. Scatter plot of Instructor One Grade vs. Automated grade (Turn Task)

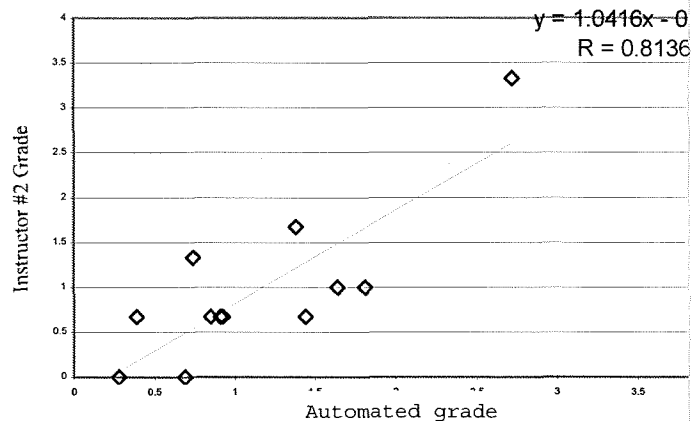


Figure 4. Scatter plot of Instructor Two Grade vs. Computer Automated Grade (Turn Tasks)

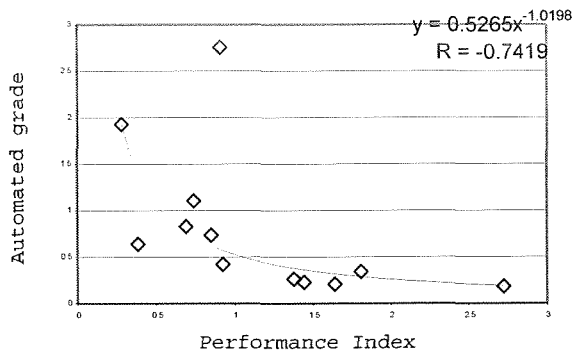


Figure 5. Scatter plot of Automated Grade (AG) vs. Performance Index (PI) (Turn Task)

There exists a negative correlation of the automated score with the performance index. This should be expected as the performance index has an inverse relationship with both the instructor grades and the automated score. However, the best-fit regression more resembles a curve of the form: $AG = 0.5265PI^{(-1.0198)}$ (Figure 5).

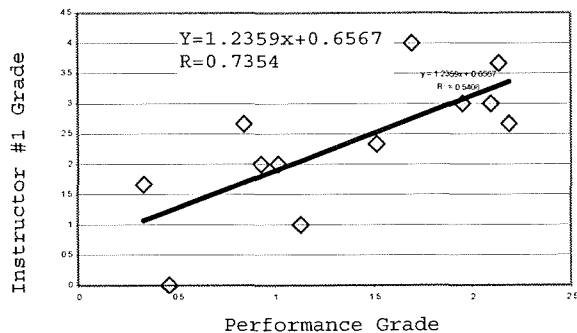


Figure 6. Scatter plot of Instructor #1 Grade vs. Performance Grade (Turn Task)

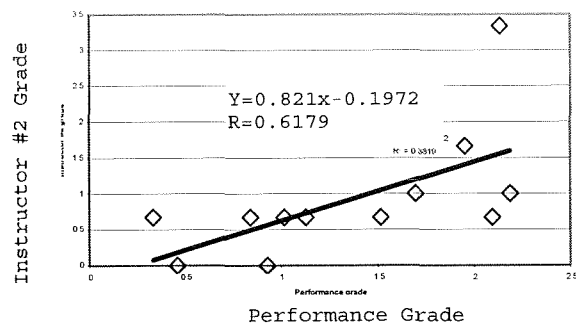


Figure 7. Scatter plot of Instructor #2 Grade vs. Performance Grade (Turn Task)

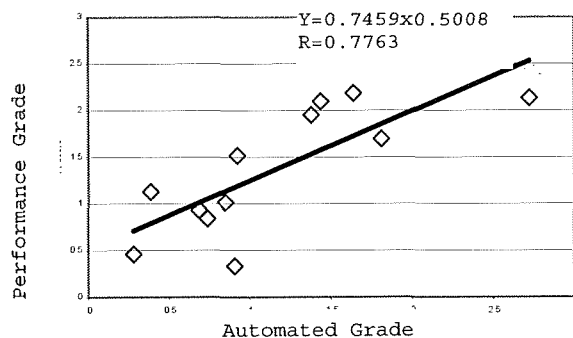


Figure 8. Scatter plot of Performance Grade vs. Automated Grade (Turn Task)

In order to obtain some reasonable 4 point scale score we used an equation of the form $A/(B+P.I.)$ and the values tried for A and B were such that $B = 0.25 \cdot A$.

The formula: $1.0/(0.25 + P.I.)$ seems to be better suited for the purpose of determining performance grade from performance index. This formula was used after several attempts with other similar formulae. Most of the P.I. values seemed to match with 0.25.

The performance grades appear to correlate well with the automated grades and the automated grades correlate well with the averaged instructor

grades. The instructor #1's grades correlate better with the performance grade than does instructor #2's grades. In general instructor #2's grades don't seem to correlate well with any of our computer grading measures.

This analysis suggests that letter-grades may not be appropriate for tracking training progress as for novices the improvements are incremental. Thus they may exhibit improvements in controlling individual flight parameters but still the overall 'letter' grade may not show an improvement in overall skill. Although the correlations are moderate to high between instructors, the instructors both seem to have a systematic difference between their score and the automated grade. Further, the differences in correlations on different parameters between instructors and the computer grade suggests that perhaps, the instructors are making evaluations based on different factors from each other. Thus the factors influencing the assessments of the instructors need to be understood. Future studies could systematically address these issues.

A failed attempt was made for a power regression between the two instructors grades and the performance index.

An increase in performance grades for a level turn corresponds with an increase in performance for a novice pilot. Therefore, they can be considered for further study for the evaluation of progress in training of level turns in simulators.

CONCLUSION

Four kinds of grading have been obtained and compared for evaluating level turn flights performed by novice pilots in a simulator. They are: instructor's grades, automated grades, performance index and performance grades. Instructor's grades are the grades provided by a certified flight instructor. Automated grades are based on prescribed tolerances in bank angle, altitude and airspeed. The performance index (P.I.) is created using the square root of the sum of the squares of dimensionless deviations in altitude and bank angle. Performance grade, which is defined as $1/(0.25 + P.I.)$, provides a reasonable 4-point grading scale. The comparison of performance grades with the other three performance measures, leads to the suggestion that they deserve further study for the evaluation of progress in training of level turns in simulators.

ACKNOWLEDGEMENTS

This work was sponsored by two NASA DFRC grants: NAG4 203 and NAG4 226. The U.S. Air Force provided the consulting support of their Aviation Psychologist, Dr. Peter Crane. Mr. Mayard Williams conducted the experiment involving volunteer Tuskegee University students. Dr. Larry Moore provided video recording services. Certified Flight Instructors, Mr. Antonio Smith of Air Tuskegee, LTD. and Mr. E. Scott Barland independently graded the flights. Dr. Khan, Dr. Ali and Dr. Rossi remained available to the authors for guidance in the creation of this work. The authors wish to thank

all of these contributors for their tireless effort.

REFERENCES

Ali, S.F., Khan, M.J., Rossi, M., Crane, P., Guckenberger, D., and Bageon, K. (2001). Effects of Above Real Time Training (ARTT) on Individual Skills and Contributions to Crew/Team Performance, Final Report on NASA DFRC NAG4 169 Grant.

Federal Aviation Administration (1995). Private Pilot for Airplane Single-Engine Land Practical Test Standards, FAA-S-8081-145, Office of Flight Operations, Washington, DC.

Vreuls, D. and Obermayer, R.W. (1985) Human System Performance Measurement in Training Simulator. Human Factors, v27, n3, p.244-250

Williams, M. (2000). Above Real Time Training and Self-Instructions for Flying on a Fidelity Validated Simulator,. MS Thesis, Tuskegee University, Tuskegee, Alabama

BIOGRAPHIES

Bruce Heath is a graduate student in Mechanical Engineering at Tuskegee University and is currently researching training of novice pilots on simulators. Bruce has work experience with NVR Inc., in the Information Technology field. He has a BS from Tuskegee University in Aerospace Engineering and a BS (cum laude) in Airway Science from University of Maryland Eastern Shore.

Tomyka Crier has a BS in Aerospace Science Engineering from Tuskegee University. Her experiences include conceptual design projects for university customers such as NASA and the Boeing Company. During a co-op at NASA Kennedy Space Center, she worked as an Avionics Trainee in a Guidance, Navigation, and Control group. While currently enrolled in the Master of Mechanical Engineering program, she concentrates on aerospace simulation topics.